

2013 Annual Report**PI: Derek Lovely, University of Massachusetts****ONR Award: N000141210229****Title: Mechanisms Underlying the Metallic-Like Conductivity of Microbial Nanowires****Scientific and Technical Objectives**

The overall objective of this research is to elucidate the mechanisms for the metal-like conductivity of *Geobacter sulfurreducens* pili in order to understand this novel biological phenomenon and to provide information for optimizing practical applications of pili or pili mimetics. Specific short-term objectives are to: 1) investigate the mechanisms underlying metal-like conductivity; 2) develop a structural understanding of the pili to probe the conduction mechanism at a molecular level; and 3) identify strategies for increasing the conductance of pili.

Approach

(b) (4)

Concise Accomplishments

(b) (4)

Expanded Accomplishments

(b) (4)

(b) (4)

(b) (4)

Work Plan

(b) (4)

Major Problems

None

Technology Transfer

None yet, but structural information related to pili conductivity is likely to lead to patentable synthetic designs of pili, with enhanced conductivity.

Foreign Collaborations and Supported Foreign Nationals

Nikhil Malvankar is the primary postdoctoral researcher working on this project.

Productivity

Publications:

Nikhil S. Malvankar, Mark T. Tuominen and Derek R. Lovley. 2012. Lack of Cytochrome Involvement in Long-Range Electron Transport through Conductive Biofilms and Nanowires of *Geobacter sulfurreducens*. *Energy Environ. Sci.* 5:8651-8659.

Derek R. Lovley. 2012. Long-range electron transport to Fe(III) oxide via pili with metallic-like conductivity. *Biochemical Society Transactions.* 40:1186-1190.

Nikhil S. Malvankar, Joanne Lau, Kelly P. Nevin, Ashley E. Franks, Mark T. Tuominen and Derek R. Lovley. 2012. Electrical Conductivity in a Mixed-Species Biofilm. *Appl. Environ. Microbiol.* 78:5967-5971.

Madeline Vargas, Nikhil S. Malvankar, Pier-Luc Tremblay, Ching Leang, Jessica A. Smith, Pranav Patel, Oona Synoeyenbos-West, Kelly P. Nevin, and Derek R. Lovley. 2013. Aromatic Amino Acids Required for Pili Conductivity and Long-Range Extracellular Electron Transport in *Geobacter sulfurreducens*. *mBio.* 4:e00105-13.

Ching Leang, Nikhil S. Malvankar, Ashley E. Franks, Kelly P. Nevin and Derek R. Lovley. 2013. Engineering *Geobacter sulfurreducens* to Produce a Highly Cohesive Conductive Matrix with Enhanced Capacity for Current Production. *Energy Environ. Sci.* 6:1901-1908

Nikhil S. Malvankar, Sibel Ebru Yalcin, Mark T. Tuominen and Derek R. Lovley. 2013. Visualization of charge propagation along individual pili proteins using ambient electrostatic force microscopy. *Nature Nanotechnology.* (Submitted)

Presentations at Scientific Meetings:

*Designates invited talk

*Nikhil S. Malvankar, Madeline Vargas, Mark T. Tuominen, Derek R. Lovley. Discovery of nanostructured natural organic metals with applications for fuel cells, transistors and supercapacitors. International Conference on Science and Technology of Synthetic Metals (ICSM), Atlanta, Georgia, 8-13 July 2012.

*Derek R. Lovley . Electromicrobiology: new paradigms for long-range extracellular electron transport and interspecies electron transfer. *International Society of Microbial Ecology (ISME)*, Copenhagen, Denmark, 19-24 August 2012.

Nikhil S. Malvankar, Gary M. King and Derek R. Lovley. Direct measurements of conductivity in marine sediments suggest long-range electron transport via minerals rather than microbial nanowires. *International Society of Microbial Ecology (ISME)*, Copenhagen, Denmark, 19-24 August 2012.

*Nikhil S. Malvankar, Meal-like transport in proteins: A new paradigm for biological electron transfer and bioelectronics, Rock & Cell: From the Meso- to the Nanoscale with X-ray Spectromicroscopy workshop, *Brookhaven National Laboratory*, National Synchrotron Light Source 17-18 September 2012.

Nikhil S. Malvankar, Sibel E. Yalcin, Madeline Vargas, Mark T. Tuominen, Derek R. Lovley. Nanoscopic approach for establishing the mechanism of electron exchange among microbial communities. Symposium on Cellular Complexity, University of Massachusetts Amherst, October, 2012.

Madeline Vargas, Nikhil S. Malvankar, Pier-Luc Tremblay, Ching Leang, Jessica A. Smith, Pranav Patel, Oona Synoeyenbos-West, Kelly P. Nevin, and Derek R. Lovley. Key Aromatic Amino Acids Required for Conduction Along Pili of *Geobacter sulfurreducens*. North American Meeting of the International Society for Microbial Electrochemistry and Technology (ISMET). Cornell University. October 2012.

*Derek R. Lovley. Optimizing Microbe-Electrode and Cell-Cell Electrical Contacts for Bioenergy and Biosensor Applications North American Meeting of the International Society for Microbial Electrochemistry and Technology (ISMET). Cornell University. October 2012.

*Derek R. Lovley. Electromicrobiology: Implications for Biogeochemistry and Bioenergy. Francis E. Clark Distinguished Lectureship On Soil Biology. American Society for Agronomy, Crop Science Society of America, and Soil Science Society of America International Annual Meetings. Cincinnati, Ohio. October 2012.

*Derek R. Lovley. Electromicrobiology: Long-Range Extracellular Electron Transport Through Protein Filaments with Metallic-Like Conductivity. Workshop on Semiconductor Concepts from Synthetic Biology. Cambridge, MA. February 2013.

*Nikhil S. Malvankar. Metal-like transport in proteins: A new paradigm for biological electron transfer and bioelectronics. Department of Biosciences and Bioengineering. Indian Institute of Technology, Bombay, March 4, 2013.

Nikhil S. Malvankar, Sibel E. Yalcin, Madeline Vargas, Mark T. Tuominen, Derek R. Lovley. Direct observation and quantification of extracellular long-range electron flow in anaerobic bacteria. American Physical Society Meeting, Baltimore, MD. March 2013.

Madeline Vargas, Nikhil S. Malvankar, Pier-Luc Tremblay, Ching Leang, Jessica A. Smith, Pranav Patel, Oona Synoeyenbos-West, Kelly P. Nevin, and Derek R. Lovley. Aromatic Amino Acids Required for Pili Conductivity and Long-Range Extracellular Electron Transport in *Geobacter sulfurreducens*. *American Society of Microbiology* General meeting, May 2013. Denver, CO.

F. Patents

None

G. Awards/Honors

mBio paper was featured as an ‘editors pick’”

XI. Award Participants

Nikhil S. Malvankar

Derek R. Lovley